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(54) **CARGO DOOR ELECTRICAL CONTROL AND WARNING INDICATION SYSTEM AND METHOD OF USE**

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(51) **Int. Cl.**[7] **G08B 21/00**
(52) **U.S. Cl.** **340/945**; 340/963; 340/964; 340/980; 340/426; 340/542; 340/545.1; 244/129.3; 244/129.4; 244/129.5
(58) **Field of Search** 340/945, 946, 340/948, 952, 953, 959, 960, 963, 964, 980, 982, 426, 542, 545.1; 244/129.5, 129.4, 129.3

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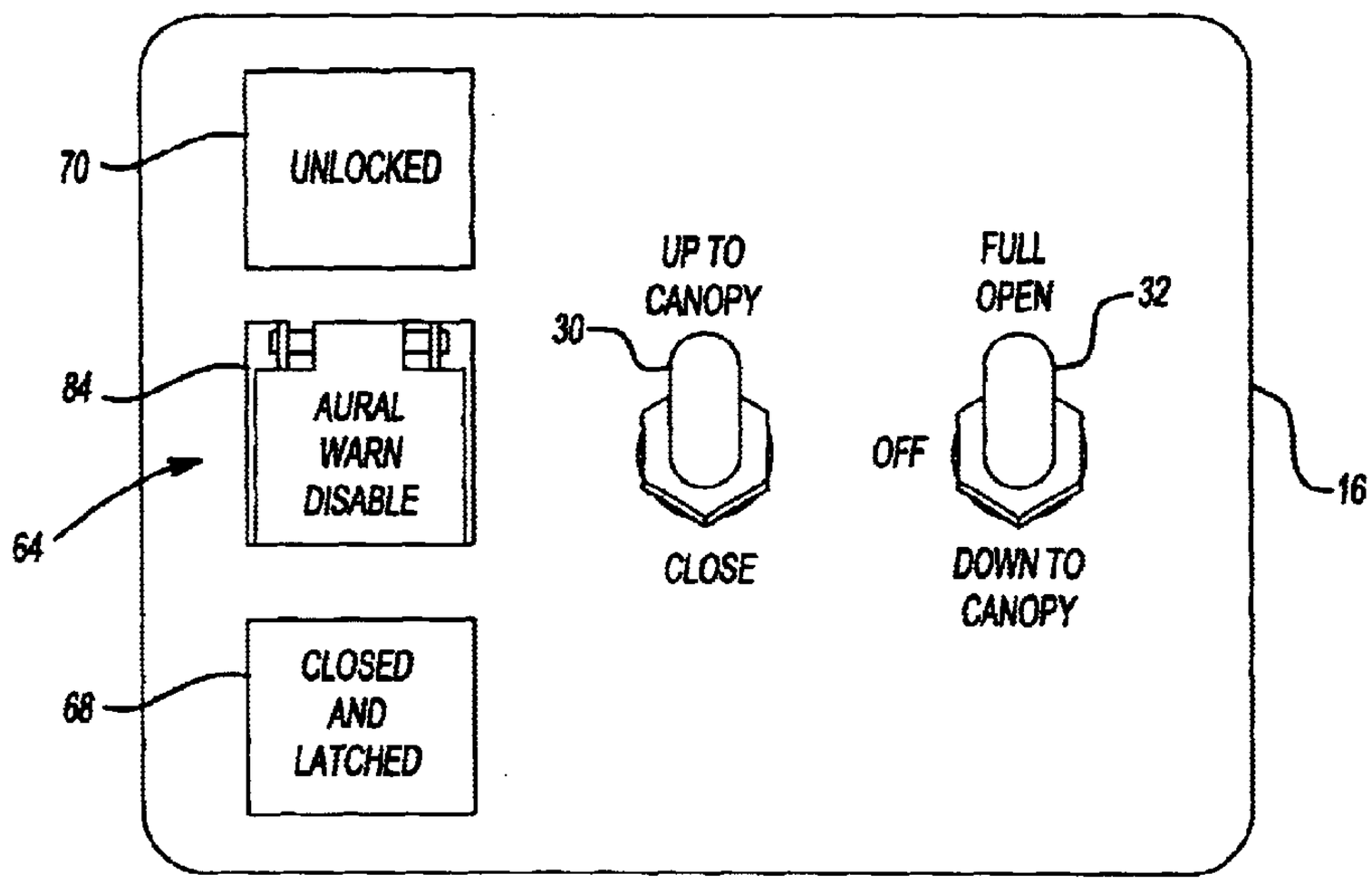
(57) **ABSTRACT**

A warning indication system and method of using the same in conjunction with a cargo door of an aircraft. The cargo door is positionable in an opened position; a closed position; a closed and latched position; and a closed, latched, and locked position. The method includes outputting first and second closed signals when the cargo door is in the closed position; outputting first and second latched signals when the cargo door is in the closed and latched position; and outputting first and second locked signals when the cargo door is in the closed, latched, and locked position. All of the signals are then analyzed to positively determine the position of the cargo door, while minimizing the probability of false indications. Various warnings are generated in response to the combination of signals received. The apparatus employs a dual logic system and redundant sensors to provide differing warnings dependent on the phase of flight.

17 Claims, 7 Drawing Sheets



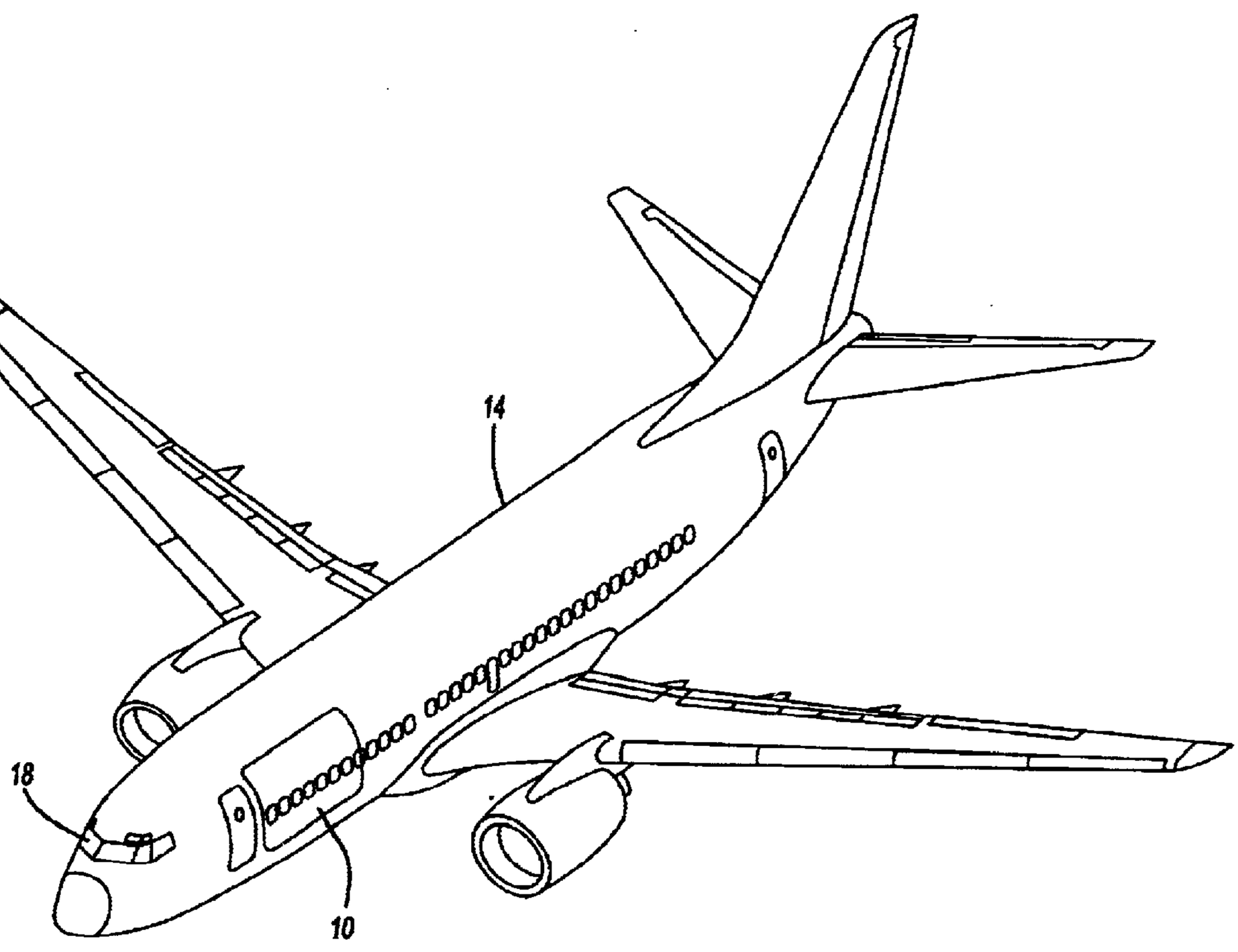


Fig-1

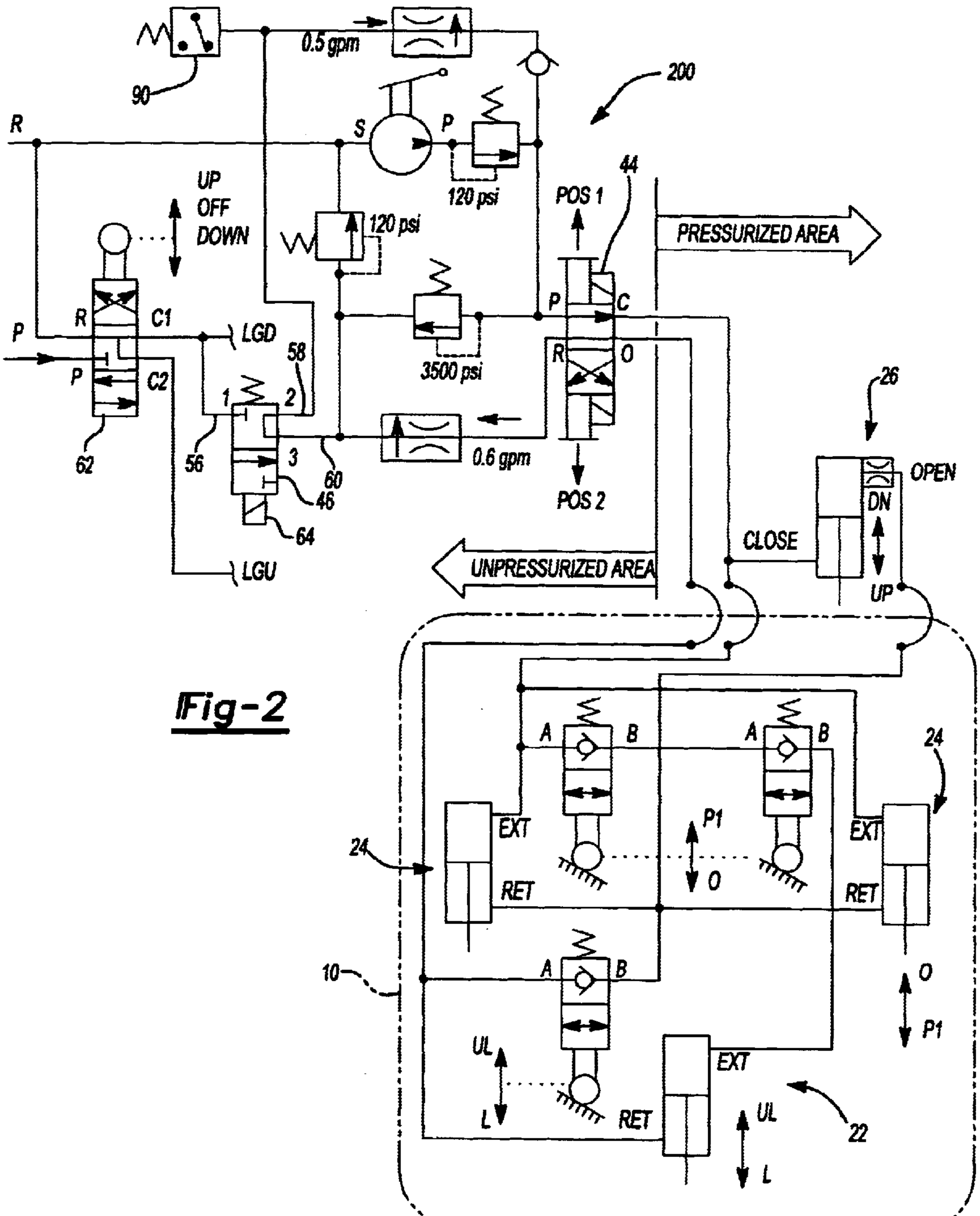

0.5 gpm
90
200
R
S
P
120 psi
UP
OFF
DOWN
120 psi
44
POS 1
PRESSURIZED AREA
P
C
R
C1
LGD
58
P
C2
1
2
3
R
O
3500 psi
26
62
56
60
46
64
0.6 gpm
POS 2
OPEN
DN
CLOSE
UP
LGU
UNPRESSURIZED AREA
A
B
EXT
RET
24
P1
O
10
UL
L
22

Fig-2

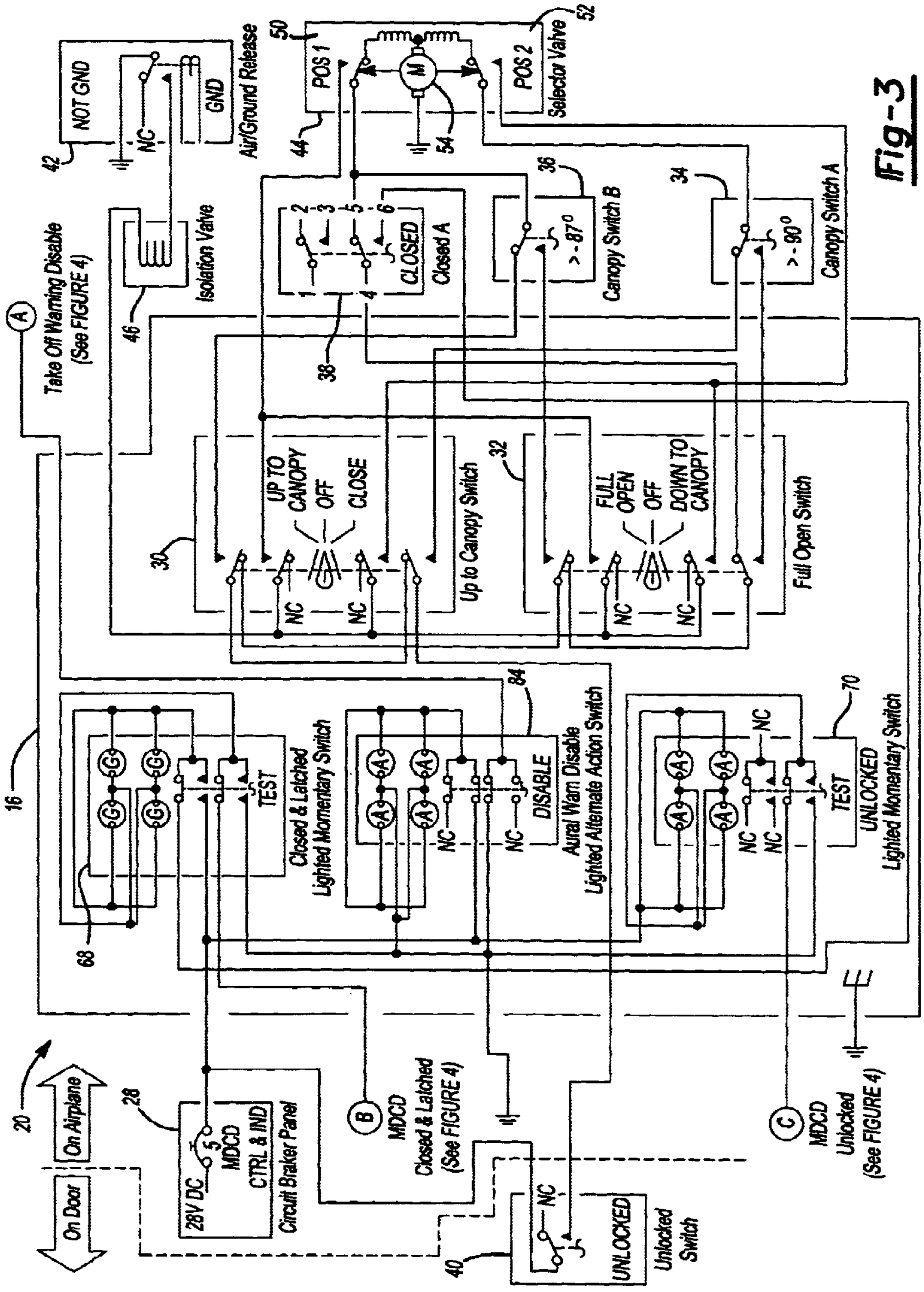

NOT GND
NC
GND
Air/Ground Release
42
50
POS 1
POS 2
Selector Valve
52
M
44
54
36
34
Canopy Switch B
Canopy Switch A
> - 87°
> - 90°
2
3
5
6
1
4
CLOSED
Closed A
Take Off Warning Disable
(See FIGURE 4)
A
46
Isolation Valve
38
UP TO CANOPY
OFF
CLOSE
30
Up to Canopy Switch
32
FULL OPEN
OFF
DOWN TO CANOPY
Full Open Switch
NC
84
16
TEST
Closed & Latched
Lighted Momentary Switch
DISABLE
Aural Warn Disable
Lighted Alternate Action Switch
70
UNLOCKED
Lighted Momentary Switch
Main Deck Cargo Door Control Panel
68
20
On Airplane
On Door
28
28V DC
5
MDCD
CTRL & IND
Circuit Braker Panel
B
MDCD
Closed & Latched
(See FIGURE 4)
40
UNLOCKED
Unlocked
Switch
C
MDCD
Unlocked
(See FIGURE 4)

Fig-3

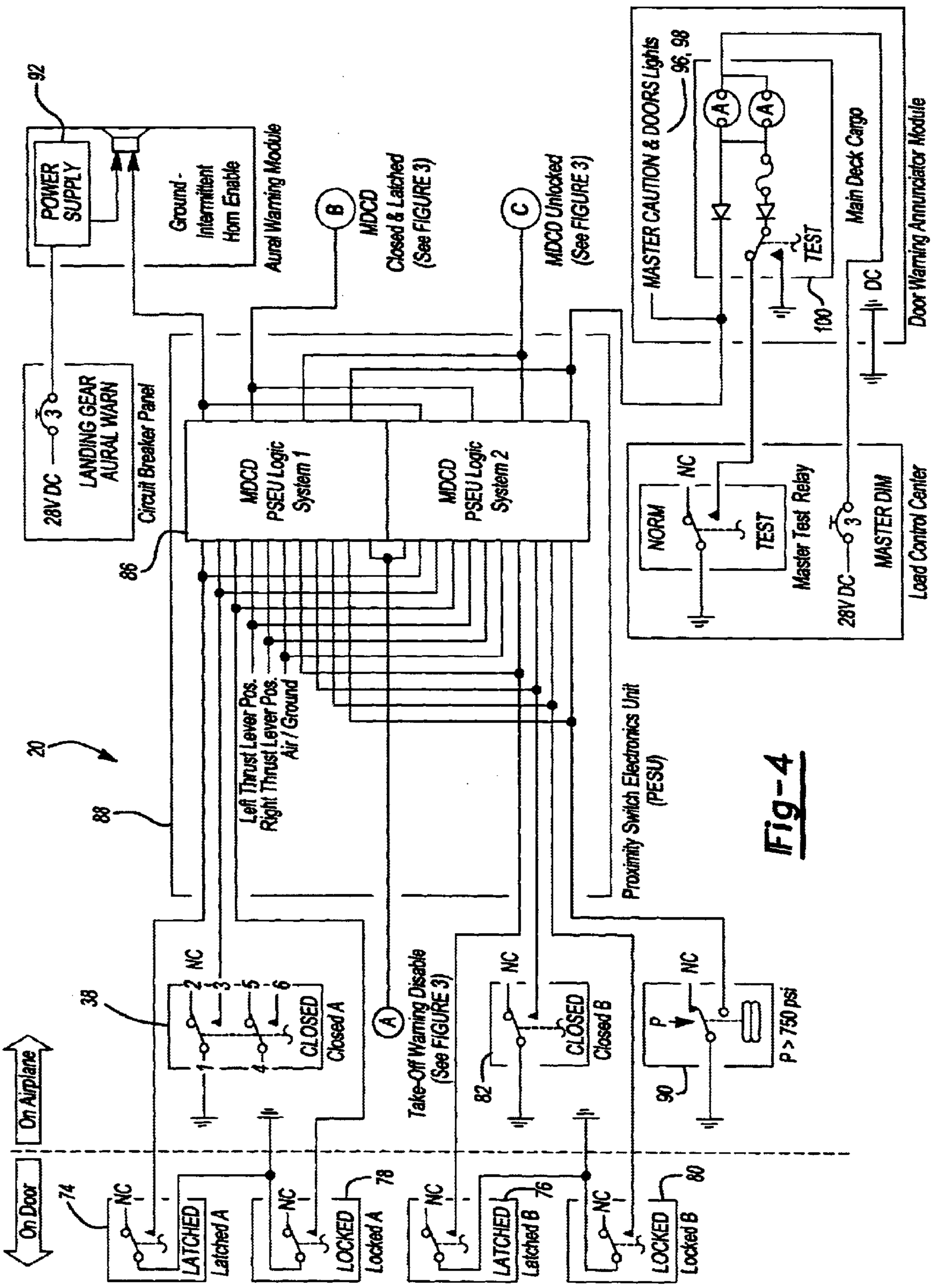
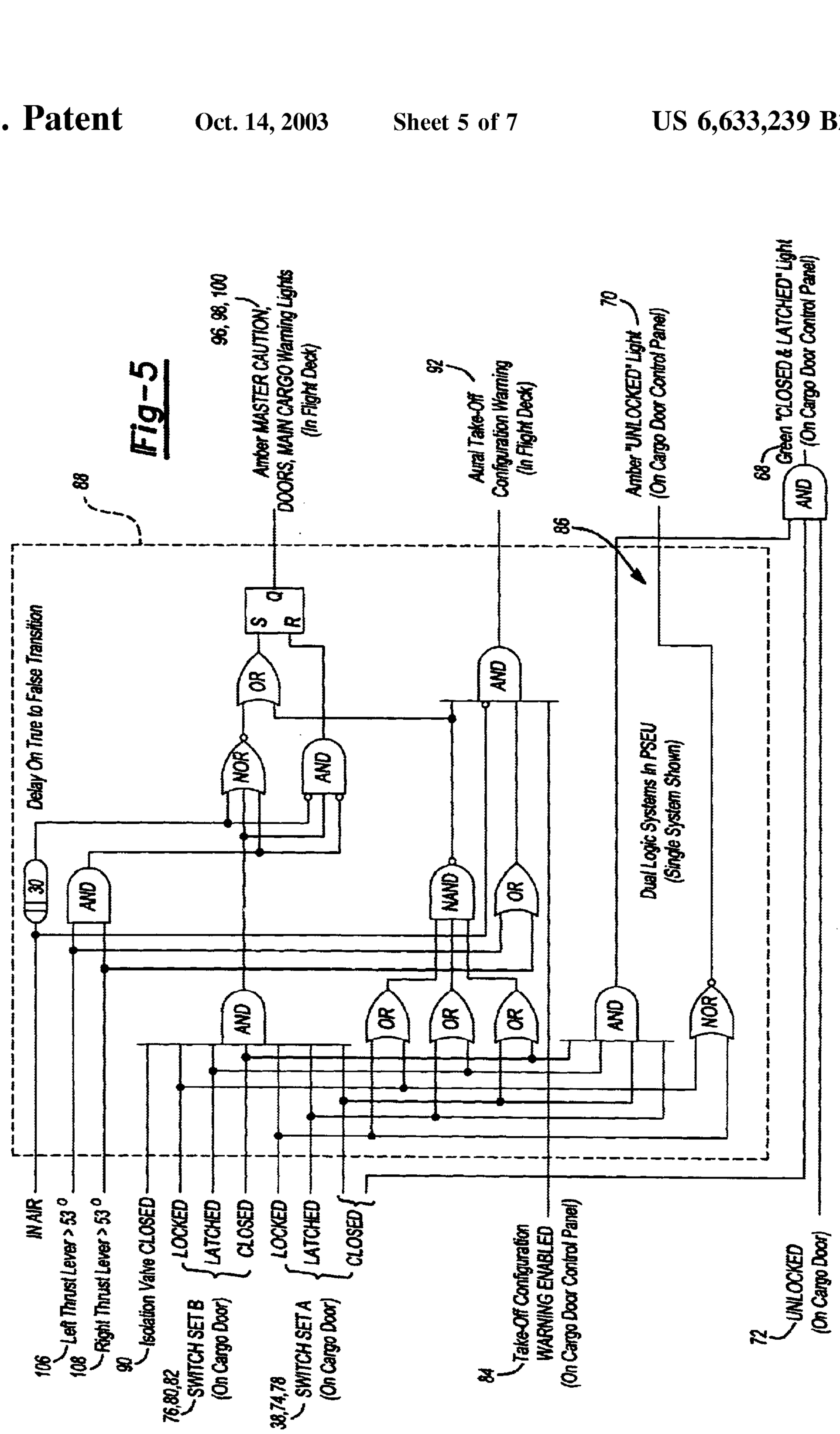

20
92
POWER SUPPLY
28V DC
3
LANDING GEAR AURAL WARN
Circuit Breaker Panel
Ground - Intermittent Horn Enable
Aural Warning Module
B
MDCD Closed & Latched (See FIGURE 3)
C
MDCD Unlocked (See FIGURE 3)
MASTER CAUTION & DOORS Lights
96, 98
TEST
100
Main Deck Cargo Door Warning Annunciator Module
MDCD PSEU Logic System 1
MDCD PSEU Logic System 2
86
NORM
NC
TEST
Master Test Relay
28V DC
3
MASTER DIM
Load Control Center
88
Left Thrust Lever Pos.
Right Thrust Lever Pos.
Air / Ground
Proximity Switch Electronics Unit (PESU)
38
NC
2
3
5
6
1
4
CLOSED
Closed A
A
Take-Off Warning Disable (See FIGURE 3)
82
NC
CLOSED
Closed B
P
NC
90
P > 750 psi
On Airplane
On Door
74
NC
LATCHED
Latched A
NC
LOCKED
Locked A
78
NC
LATCHED
Latched B
76
NC
LOCKED
Locked B
80

Fig-4

Fig-5


Delay On True to False Transition
88
30
AND
106
IN AIR
108
Left Thrust Lever > 53°
Right Thrust Lever > 53°
90
Isolation Valve CLOSED
76,80,82
SWITCH SET B
(On Cargo Door)
LOCKED
LATCHED
CLOSED
38,74,78
SWITCH SET A
(On Cargo Door)
LOCKED
LATCHED
CLOSED
84
Take-Off Configuration
WARNING ENABLED
(On Cargo Door Control Panel)
72
UNLOCKED
(On Cargo Door)
96, 98, 100
Amber MASTER CAUTION,
DOORS, MAIN CARGO Warning Lights
(In Flight Deck)
92
Aural Take-Off
Configuration Warning
(In Flight Deck)
86
Dual Logic Systems In PSEU
(Single System Shown)
70
Amber "UNLOCKED" Light
(On Cargo Door Control Panel)
68
Green "CLOSED & LATCHED" Light
(On Cargo Door Control Panel)
S
Q
R
OR
NOR
AND
NAND
OR
OR
OR
OR
AND
AND
NOR

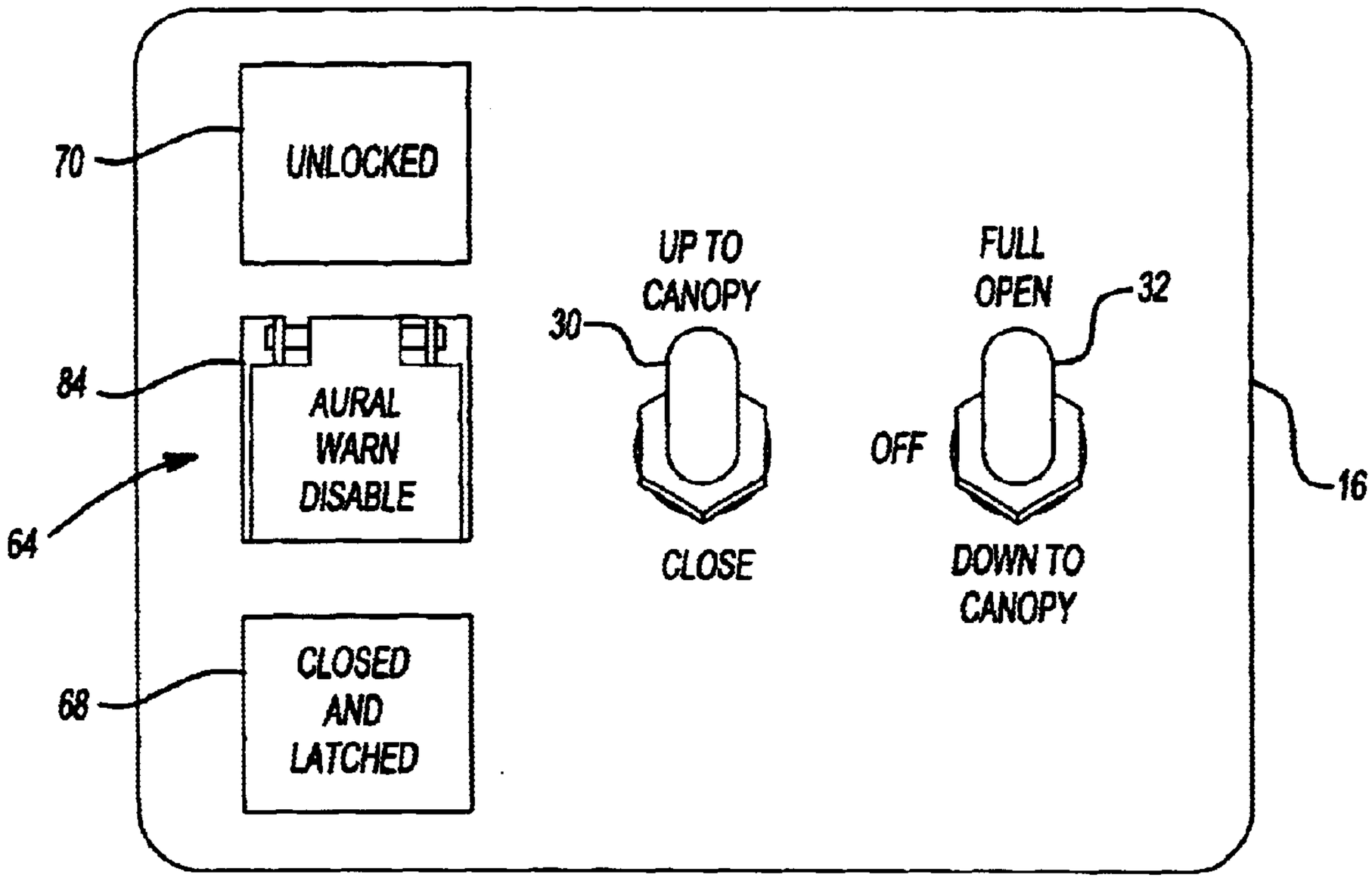

70
UNLOCKED
84
AURAL WARN DISABLE
64
68
CLOSED AND LATCHED
UP TO CANOPY
30
CLOSE
FULL OPEN
32
OFF
DOWN TO CANOPY
16

Fig-6

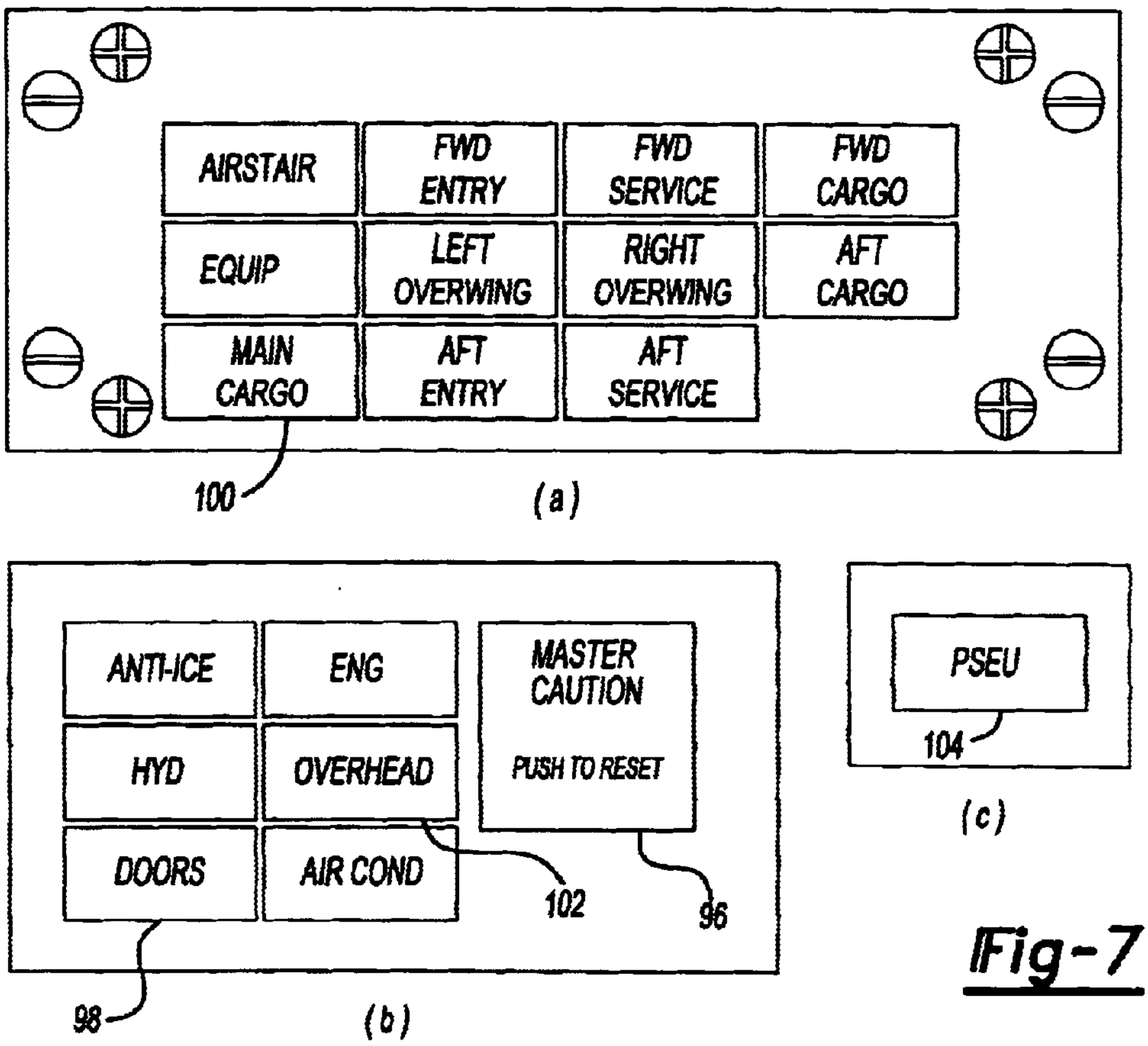

AIRSTAIR
FWD ENTRY
FWD SERVICE
FWD CARGO
EQUIP
LEFT OVERWING
RIGHT OVERWING
AFT CARGO
MAIN CARGO
AFT ENTRY
AFT SERVICE
100
(a)
ANTI-ICE
ENG
MASTER CAUTION
PUSH TO RESET
HYD
OVERHEAD
DOORS
AIR COND
102
96
98
(b)
PSEU
104
(c)

Fig-7

Fig-8

Fault Timing ⇨ / Fault Condition ⇩	Fault Occurs on Ground (Prior to Takeoff Thrust Set or 30 Seconds After Landing)	Fault Occurs on Ground (After Takeoff Thrust Set)	Fault Occurs in Flight (After Transition to Air Mode until 30 Seconds After Transition to Ground Mode)
A Single Switch (1 of 6) in Either Channel A or B Indicates Not Closed, or Not Latched, or Not Locked; or 38, 74, 76, 78, 80, 82 Pressure Not Isolated 46	96 MASTER CAUTION 98 DOORS 100 MAIN CARGO *	No Indication for New Faults	No Indication for New Faults
Multiple Non-Redundant Switches (up to 3 of 6) In Either Channel A or B Indicate Not Closed, or Not Latched, or Not Locked; or 38, 74, 76, 78, 80, 82 Pressure Not Isolated 46	96 MASTER CAUTION 98 DOORS 100 MAIN CARGO *	No Indication for New Faults.	No Indication for New Faults.
Redundant Switches in Channels A and B Both Indicate Not Closed, or Not Latched, or Not Locked 38 and 82 or 74 and 76, or 78 and 80	96 MASTER CAUTION 98 DOORS 100 MAIN CARGO *	96 MASTER CAUTION 98 DOORS 100 MAIN CARGO * Takeoff Config. Aural Warning	96 MASTER CAUTION 98 DOORS 100 MAIN CARGO *
A Single Switch (1 of 6) in Either Channel A or B Falsely Indicates Closed or Latched or Locked *** 38, 74, 76, 78, 80, 82 or Aural Warn Disable 84 Enabled	96 MASTER CAUTION 98 OVERHEAD ** 100 PSEU **	N/A	N/A

* Once Main Cargo is Lit, the Light Will Remain Lit.

** The "Dispatchable" PSEU Light and OVERHEAD Light Will Illuminate During Master Caution Recall Prior to Takeoff.

*** Only Detected During Operation of the Door (i.e., Cycling from closed to open).

CARGO DOOR ELECTRICAL CONTROL AND WARNING INDICATION SYSTEM AND METHOD OF USE

FIELD OF THE INVENTION

The present invention generally relates to aircraft cargo doors and, more particularly, relates to an electrical control and warning indication system for use with an aircraft cargo door that employs and a method of using the same.

BACKGROUND OF THE INVENTION

According to the Federal Aviation Administration (FAA), the certification requirements of warning systems on outwardly opening cargo doors state that erroneous closed, latched, and locked indication (i.e., the loss of indication) must be shown to be "improbable", which generally means having a probability of occurrence of less than or equal to 1 per 100,000 flights. Although the current text of the rules do not explicitly require it, it has recently been required by regulatory agencies that the manufacturer of airplanes with outwardly opening cargo doors demonstrate that nuisance indication is also "improbable." In addition, regulatory agencies have expended significant effort to reduce occurrences of unnecessary rejected takeoffs resulting from nuisance warning indications.

It has been possible to meet, although marginally, the improbable erroneous indication requirements with existing single channel indication systems. However, it has not always been possible to meet the requirements that nuisance indication also be improbable. In the instances where it was not possible to comply fully with the nuisance indication requirement, the regulatory agencies involved have noted the difficulty in meeting this requirement and have accepted this limitation.

With reference to single channel systems, it is not generally possible to determine if a warning is accurate, or not, nor has it been possible to reduce the probability of both erroneous and nuisance indication. Because of these limitations, significant reductions in the occurrence of rejected takeoffs due to false cargo door indications have not been realized.

The indication systems on outwardly opening, cargo doors having cam-type latches have historically been single channel systems. Because of this, these single channel systems have not been able to determine if the closed, latched, or locked status of the cargo door is erroneous or not. Therefore, if either of the closed, latched, or locked state of the cargo door should transition to the inverse state, a warning message must be provided. If this indication is erroneous, and occurs during the takeoff roll, a risky heavy weight rejected takeoff must be performed.

Closed, latched, and locked status indications of a cargo door is often provided at a cargo door operator's control panel near the cargo door opening. An example of such an indication system is provided in U.S. Pat. No. 5,735,487, commonly owned herewith, the disclosure of which is incorporated herein by reference. However, known control panels have not incorporated features to deactivate the warnings if faults are detected prior to flight and the airplane is being dispatched per Minimum Equipment List conditions with the warning system working improperly.

Accordingly, there exists a need in the relevant art to provide visual and aural warning indications relative to the safety status of an outwardly opening cargo door on transport category airplanes. Moreover, there exists a need in the relevant art to provide a warning indication system that is capable of distinguishing whether a warning indication is false, thereby reducing the occurrence of unnecessary rejected takeoffs. Furthermore, there exists a need in the relevant art to provide a warning indication system that overcomes the disadvantages of the prior art systems.

SUMMARY OF THE INVENTION

According to the principles of the present invention, a cargo door electrical control and warning indication system having an advantageous construction and method of use is provided. The warning indication system is adapted for use with a cargo door of an aircraft. The cargo door being positionable in an opened position; a closed position; a closed and latched position; and a closed, latched, and locked position. The method includes outputting first and second closed signals when the cargo door is in the closed position; outputting first and second latched signals when the cargo door is in the closed and latched position; and outputting first and second locked signals when the cargo door is in the closed, latched, and locked position. All of the signals are then analyzed to positively determine the position of the cargo door, while minimizing the probability of false indications. Various warnings are generated in response to the combination of signals received. The apparatus employs a dual logic system and redundant sensors to provide differing warnings dependent on the phase of flight.

Further areas of applicability of the present invention will become apparent from the detailed description provided hereinafter. It should be understood that the detailed description and specific examples, while indicating the preferred embodiment of the invention, are intended for purposes of illustration only and are not intended to limit the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will become more fully understood from the detailed description and the accompanying drawings, wherein:

FIG. **1** is a perspective view of an airliner incorporating a cargo door electrical control and warning indication system according to the principles of the present invention;

FIG. **2** is a fluid circuit diagram illustrating the warning indication system of the present invention;

FIG. **3** is an electrical control circuit diagram illustrating the cargo door electrical control and warning indication system according to the principles of the present invention;

FIG. **4** is an electrical warning indication circuit diagram illustrating the cargo door electrical control and warning indication system according to the principles of the present invention;

FIG. **5** is a warning indication logic diagram illustrating the cargo door electrical control and warning indication system according to the principles of the present invention;

FIG. **6** is a front view of a door operator's control panel according to the present invention;

FIG. **7***a* is a front view of a flight deck forward overhead warning panel according to the present invention;

FIG. **7***b* is a front view of a flight deck glareshield warning panel according to the present invention:

FIG. **7***c* is a front view of a flight deck aft overhead warning panel according to the present invention; and

FIG. **8** is a warning indication logic table illustrating the warning indication according to various timing conditions.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following description of the preferred embodiment is merely exemplary in nature and is in no way intended to limit the invention, its application, or uses. For example, cargo door **10** warning indication system of the present invention may find utility in a wide range of applications, such as in use with a cargo aircraft, a convertible aircraft, and the like. Although the following description is directed to the warning system as it is used in a conventional, convertible, large-capacity, commercial airliner, the warning system should not be construed to be limited to such applications.

Referring to the figures, a cargo door **10** is an electrically controlled, hydraulically actuated, outwardly opening, non-plug cargo door. Cargo door **10** opens to two positions in order to provide a clear opening for loading and unloading of containerized and/or palletized cargo into and out of a main deck compartment of an aircraft **14**. Indication of the closed, latched, and locked status of cargo door **10** is provided at both an door operator control panel **16** and on a flight deck **18**. Appropriate colors, in combination with text on the warning and status lights, are used to warn cargo door **10** operator and the flight crew when cargo door **10** is in an unsafe configuration.

Electrical Control System

With particular reference to FIGS. **2**, **3**, and **6**, an electrical control and indication system **20** provides the power required for normal operation of a hydraulic latch mechanism **22**, hydraulic pull-in mechanisms **24**, and a hydraulic lift mechanism **26**. Control and indication system **20** consists of a circuit breaker **28**, an UP TO CANOPY switch **30**, a FULL OPEN switch **32**, a first canopy switch **34**, a second canopy switch **36**, a door closed A switch **38**, a door unlocked switch **40**, an air/ground relay **42**, and two electrically controlled hydraulic valves, specifically a motor operated selector valve **44** and a solenoid operated isolation valve **46**. To electrically command cargo door **10** to open or close, the following conditions must be met: 1) aircraft **14** must be on the ground; 2) the landing gear selector lever must be positioned in the DOWN position (see valve **62** in FIG. **2**); 3) the hydraulic system must be operating; 4) there must be 28V DC available from circuit breaker **28**; and 5) a lock and vent panel mechanism (not shown) must be in the unlocked position, which causes door unlocked switch **40** to be in the UNLOCKED position.

As best seen in FIG. **6**, UP TO CANOPY switch **30** and FULL OPEN switch **32** are located on door operator control panel **16**. Door operator control panel **16** is located just inside cargo door **10**. UP TO CANOPY switch **30** and FULL OPEN switch **32** are momentary make, three-position, spring loaded, center-off, toggle switches. UP TO CANOPY switch **30** controls cargo door **10** operation up to a canopy position and back to a closed position. FULL OPEN switch **32** controls cargo door **10** operation from the canopy position up to a fully opened position and back to canopy position. UP TO CANOPY switch **30** and FULL OPEN switch **32** are operated in sequence to raise cargo door **10** to full open and to close cargo door **10**. If UP TO CANOPY switch **30** and FULL OPEN switch **32** are operated out of sequence or simultaneously, cargo door **10** will not operate. When cargo door **10** is locked, both UP TO CANOPY switch **30** and FULL OPEN switch **32** are electrically disabled by door unlocked switch **40**.

Air/ground relay **42** provides the electrical ground to enable operation of solenoid operated isolation valve **46** when aircraft **14** is on the ground. The electrical ground for control and indication system **20** is removed if the air/ground relay **42** is in the air mode (airplane in-flight and air/ground relay **42** is thus opened).

Motor operated selector valve **44** is preferably located in the right hand aft wing to body fairing compartment. Motor operated selector valve **44** is a motor driven, two-position, sequence valve with four ports and a manual override lever. Motor operated selector valve **44** has two internal double pole switches **50**, **52**. The two positions of motor operated selector valve **44** are identified as POS **1** (door open) and POS **2** (door close) and are marked adjacent to a manual override lever. Position switches **50**, **52** alternately complete power circuits to each side of a split winding in a motor **54**, thereby allowing motor **54** to drive selector valve **44** to POS **1** or POS **2**. When selector valve **44** moves to one extreme position, the switch (either **50**, **52**) connected to the driven winding is opened, thus automatically stopping motor **54**, and the switch (either **52**, **50**) connected to the opposite winding is closed when selector valve **44** leaves the opposite extreme position. Motor **54** operates on 28V DC and is protected by circuit breaker **28**.

Solenoid operated isolation valve **46** is in the same general aircraft location as motor operated selector valve **44**. Isolation valve **46** is a solenoid driven, piston-type, two-position isolation valve with three ports—a pressure port **56**, an output port **58**, and a return port **60**. Pressure port **56** is connected to the hydraulic pressure lines downstream of a landing gear selector bypass valve **62**. When a solenoid **64** of isolation valve **46** is energized, solenoid **64** moves the piston of isolation valve **46** to connect pressure port **56** to output port **58** and return port **60** is blocked. This position ports hydraulic pressure to motor operated selector valve **44**. When solenoid **64** is de-energized, the piston of isolation valve **46** connects output port **58** to return port **60** and pressure port **56** is blocked. This position, wherein pressure port **56** blocked, is the normal de-energized state of isolation valve **46**. Solenoid **64** operates on 28V DC and is protected by circuit breaker **28**.

When cargo door **10** is closed, door closed A switch **38** prevents uncommanded opening by electrically isolating cargo door **10** open (POS **1**) coil **50** of motor operated selector valve **44**. First canopy switch **34** and second canopy switch **36** are actuated in response to lift mechanism **26**. During opening of cargo door **10** to the canopy and full open positions, second canopy switch **36** provides power to POS **1** of motor operated selector valve **44** when either UP TO CANOPY switch **30** or FULL OPEN switch **32** are respectively selected to the UP TO CANOPY and FULL OPEN positions. During opening to the canopy position, as motor operated selector valve **44** transitions from POS **2** to POS **1**, power is removed from the windings of motor operated selector valve **44** and applied to solenoid operated isolation valve **46** via the internal POS **1** switch and UP TO CANOPY switch **30**. At approximately 87° of door open rotation, lift mechanism **26** actuates second canopy switch **36**, which removes power from solenoid operated isolation valve **46**, thereby stopping motion of cargo door **10**. To continue opening cargo door **10** from the canopy position (approximately 87° open) to the fully open vertical position, FULL OPEN switch **32** is placed in the FULL OPEN position. Power to solenoid operated isolation valve **46** is provided by FULL OPEN switch **32**, via second canopy switch **36** and internal POS **1** switch **50** of motor operated selector valve **44**.

To close cargo door **10** from the full open position, first canopy switch **34** provides power to POS **2** winding of

motor operated selector valve **44**, via first canopy switch **34**, when FULL OPEN switch **32** is selected to the DOWN TO CANOPY position. After motor operated selector valve **44** transitions to POS **2**, power is removed from POS **2** winding of motor operated selector valve **44** by the internal POS **2** switch and applied to open solenoid operated isolation valve **46** via FULL OPEN switch **32**. At approximately 90 degrees of door rotation, first canopy switch **34** is actuated thereby causing power to be removed from POS **2** of solenoid operated isolation valve **46**. Cargo door **10** continues to lower until it is stopped in the canopy position by ram locks, which are internal to lift mechanism **26**. As the operator removes his hand from FULL OPEN switch **32**, FULL OPEN switch **32** returns to the OFF position, which transfers power to POS **1** winding **50** of motor operated selector valve **44**, via door closed A switch **38**, until motor operated selector valve **44** moves fully to POS **1**. Since solenoid operated isolation valve **46** is closed and motor operated selector valve **44** is in POS **1**, a hydraulic block is provided that also hydraulically locks cargo door **10** in the canopy position.

To close cargo door **10** from the canopy position, UP TO CANOPY switch **30** must be placed in the CLOSE position. Placing UP TO CANOPY switch **30** in the CLOSE position provides power to the POS **2** winding of motor operated selector valve **44**. When motor operated selector valve **44** is in POS **2**, power is removed from the POS **2** winding of motor operated selector valve **44** and transferred to solenoid operated isolation valve **46**. At this point the hydraulic block is removed and hydraulic pressure is supplied to remove the locks that are internal to lift mechanism **26** allowing cargo door **10** to close.

During a closing operation, if cargo door **10** is in a position above and below the canopy position, when the operator removes his hand from either UP TO CANOPY switch **30** or FULL OPEN switch **32**, solenoid operated isolation valve **46** closes first and then motor operated selector valve **44** transitions from POS **2** to POS **1** to provide a hydraulic block to lock cargo door **10** in the intermediate position. Subsequent reapplication of either UP TO CANOPY switch **30** or FULL OPEN switch **32** to continue closing cargo door **10** causes motor operated selector valve **44** to transition from POS **1** to POS **2** to remove the hydraulic block and then solenoid operated isolation valve **46** is opened to apply door closing pressure.

Door Operator Indication System (see FIGS. **3**, **4**, **5**, and **6**)

With particular reference to FIGS. **3–6**, door operator indication system **66** provides notification to crewmembers, either a door operator or maintenance personnel, that are operating cargo door **10**, concerning the status of cargo door **10** and its mechanisms. Indication is provided by two lighted switches **68** and **70** on door operator control panel **16** (FIG. **6**). Electrical command signals to lighted switches **68**, **70** is provided by four limit switches—a door latched A switch **74**, door latched B switch **76**, door locked A switch **78**, and door locked B switch **80**—on cargo door **10** and two limit switches—first canopy switch **34**, second canopy switch **36**, door closed A switch **38**, and a door closed B switch **82**—on the door opening of the fuselage.

Lighted switches **68**, **70** on door operator control panel **16** are specifically identified as CLOSED AND LATCHED switch **68**, UNLOCKED switch **70**, and an AURAL WARN DISABLE switch **84**. UNLOCKED switch **70** is a lighted momentary switch with four amber LED's. AURAL WARN DISABLE switch **84** is a lighted, guarded, alternate action switch with four amber LED's. CLOSED AND LATCHED switch **68** is a lighted momentary switch with four green LED's. The switch function of CLOSED AND LATCHED switch **68** and UNLOCKED switch **70** is used to provide a "press to test" check of the LED's to insure the LED's are working properly.

When cargo door **10** is in a closed, latched, and locked position, both CLOSED AND LATCHED switch **68** and UNLOCKED switch **70** are extinguished on door operator control panel **16**. When cargo door **10** is unlocked, CLOSED AND LATCHED switch **68** and UNLOCKED switch **70** will illuminate on door operator control panel **16**. UNLOCKED switch **70** remains illuminated whenever cargo door **10** is unlocked. When cargo door **10** is open or unlatched, CLOSED AND LATCHED switch **68** will extinguish, and conversely it will illuminate when cargo door **10** is closed and latched. AURAL WARN DISABLE switch **84** is normally extinguished during normal door operations.

Electrical wiring connects first canopy switch **34**, second canopy switch **36**, door closed A switch **38**, door unlocked switch **40**, and motor operated selector valve **44** to CLOSED AND LATCHED switch **68** and UNLOCKED switch **70** on door operator control panel **16** and to a dual logic system **86** of a Proximity Switch Electronics Unit (PSEU) **88**. PSEU **88** receives inputs from a cargo door hydraulic system pressure switch **90**, AURAL WARN DISABLE switch **84**, door closed A switch **38**, door closed B switch **82**, door latched A switch **74**, door latched B switch **76**, door locked A switch **78**, and door locked B switch **80** that sense the position of latch mechanism **22**, pull-in mechanisms **24**, the hydraulic pressure of the cargo door control system, and cargo door **10** itself.

As described above and best seen in FIG. **4**, door unlocked switch **40**, door latched A switch **74**, door latched B switch **76**, door locked A switch **78**, and door locked B switch **80** are each disposed on cargo door **10**. Along the bottom of the door opening in the fuselage are door closed A switch **38** and door closed B switch **82**. As seen in FIGS. **2** and **4**, cargo door hydraulic system pressure switch **90** is installed in cargo door hydraulic system **200** to sense whether hydraulic pressure is being applied to cargo door **10** when it should not be (i.e., solenoid operated isolation valve **46** commanded or stuck in the energized position). The presence of a ground at any of these eight switches—**38**, **40**, **74**, **76**, **78**, **80**, **82**, **90**—is registered as a TRUE (Logic 1) condition.

Door locked A switch **78** and door locked B switch **80** are actuated in response to the lock and vent panel mechanism. Door locked A switch **78** and door locked B switch **80** provide positive indication to PSEU **88** when cargo door **10** is locked. Both door locked A switch **78** and door locked B switch **80** are located at the aft end location the locking and venting mechanism. If either or both of door locked A switch **78** and door locked B switch **80** indicate a cargo door not locked condition (Logic 0), amber UNLOCKED switch **70** on door operator control panel **16** will be illuminated.

Door unlocked switch **40** is also actuated in response to the lock and vent panel mechanism. Door unlocked switch **40** functions as electrical interlock to door operator control panel **16** to interrupt electrical current from circuit breaker **28** when cargo door **10** is locked.

Door latched A switch **74** and door latched B switch **76** are actuated in response to latch mechanism **22**. Door latched A switch **74** and door latched B switch **76** provide

positive indication to PSEU **88** when cargo door **10** is latched. Door latched A switch **74** and door latched B switch **76** are disposed at opposing ends of latch mechanism **22**.

Door closed A switch **38** and door closed B switch **82** are actuated in response to strikers (not shown) extending from the bottom edge of cargo door **10**. Door closed A switch **38** functions to interrupt electrical current to POS **1** of motor operated selector valve **44** and provides positive indication to PSEU **88** when cargo door **10** is closed (directly to PSEU **88** and via CLOSED AND LATCHED switch **68**). Door closed B switch **82** also provides positive indication to PSEU **88** when cargo door **10** is closed. Door closed A switch **38** is installed at the forward end of the lower edge of the fuselage cutout and door closed B switch **82** is at the aft end.

If either or both of door latched A switch **74** and door latched B switch **76** indicate a door not latched condition (Logic 0), or either or both of door closed A switch **38** and door closed B switch **82** indicate a door not closed condition (Logic 0), or cargo door **10** is unlocked (door unlocked switch **40** closed), then CLOSED AND LATCHED switch **68** on door operator control panel **16** will not be illuminated.

AURAL WARN DISABLE switch **84** is provide on door operator control panel **16** to deactivate a takeoff configuration aural warning module **92** (FIG. **4**) to enable aircraft **14** to be dispatched using minimum equipment list procedures, such as when control and indication system **20** has faults that can not be repaired at the current airport. When AURAL WARN DISABLE switch **84** is pressed to disable the aural warning from takeoff configuration aural warning module **92**, AURAL WARN DISABLE switch **84** will illuminate and remain illuminated until AURAL WARN DISABLE switch **84** is pressed again to enable takeoff configuration aural warning module **92**. Disabling takeoff configuration aural warning module **92** prevents subsequent faults in control and indication system **20** from causing an unnecessary rejected takeoff.

Flight Crew Indication System

As best seen in FIG. **7**, control and indication system **20** further includes a flight crew indication system **94**, which provides visual and aural warnings to the flight crew members when cargo door **10** is not fully closed, latched, and locked. To this end, PSEU **88** provides an electrical ground to illuminate a MASTER CAUTION warning indicator **96**, a DOORS warning indicator **98**, a MAIN CARGO warning indicator **100**, an OVERHEAD warning indicator **102**, and a PSEU warning indicator **104**. Aural annunciation (tone) is produced by takeoff configuration aural warning module **92**. As described above, AURAL WARN DISABLE switch **84**, which provides a logic input to PSEU **88**, is located on door operator control panel **16**.

Dual logic system **86** of Proximity Switch Electronics Unit (PSEU) **88** checks the position of cargo door **10** via door closed A switch **38**, door closed B switch **82**, door latched A switch **74**, door latched B switch **76**, door locked A switch **78**, door locked B switch **80**, and cargo door hydraulic system pressure switch **90**. The logic for each channel is graphically illustrated in FIG. **5** and summarized in FIG. **8**. When an unsafe configuration is detected, PSEU **88** provides a ground input (Logic 1) to corresponding MASTER CAUTION warning indicator **96**, DOORS warning indicator **98**, and/or MAIN CARGO warning indicator **100** and/or takeoff configuration aural warning module **92** in flight deck **18**. PSEU **88** has Built-In-Test-Equipment (BITE) to determine if there is a disagreement between the logic outputs of each channel. When an internal fault is detected, PSEU **88** provides a ground (Logic 1) to MASTER CAUTION warning indicator **96**, OVERHEAD warning indicator **102**, and/or PSEU warning indicator **104** in flight deck **18**.

MASTER CAUTION warning indicator **96**, DOORS warning indicator **98**, and MAIN CARGO warning indicator **100** illuminate when cargo door **10** is not closed, not latched, not locked, or pressure is still applied. All three warning lights illuminate when either a single, or multiple non-redundant, or redundant switch indicates not closed, not latched, or not locked on the ground prior to advancing a left trust lever position **106** or a right thrust lever position **108** beyond 53 degrees, or 30 seconds after landing as detected by air/ground relay **42**. No indication is provided for new faults when a single or multiple non-redundant switch indicates not closed, not latched, or not locked while in-flight. MASTER CAUTION warning indicator **96** also illuminates when a single switch falsely indicates in either logic system a closed, latched, or locked. False indication is detected when cargo door **10** is unlocked, unlatched, and opened by checking to see that all ground signals (Logic 1) have transitioned to Logic 0(i.e., open).

If both door closed A switch **38** and door closed B switch **82** indicated not closed, or both door latched A switch **74** and door latched B switch **76** indicate not latched, or both door locked A switch **78** and door locked B switch **80** indicate not locked, and either trust lever is advanced beyond 53 degrees on the ground, then an aural warning is generated from takeoff configuration aural warning module **92**. This is in addition to illumination of MASTER CAUTION warning indicator **96**, DOORS warning indicator **98**, and MAIN CARGO warning indicator **100** warning lights. AURAL WARN DISABLE switch **84** is operated to disable takeoff configuration aural warning module **92**. If the aural warning has been disabled, dispatchable PSEU warning indicator **104** and OVERHEAD warning indicator **102** will illuminate when the pilots do a normal Master Caution Recall prior to takeoff.

The present invention being thus described provides a warning indication system that can distinguish if the indication system is providing valid cargo door status so that unnecessary rejected takeoffs are not performed. In addition, the present invention provides a means whereby warnings for non-significant failures that occur during the takeoff roll and in flight, are identified and stored for subsequent display upon landing. The present invention still further provide a means to deactivate the aural warning if faults are detected in the warning circuit before flight, while simultaneously providing a visual warning to the pilots in flight deck **18** that deactivation of the aural warning is active.

The description of the invention is merely exemplary in nature and, thus, variations that do not depart from the gist of the invention are intended to be within the scope of the invention. Such variations are not to be regarded as a departure from the spirit and scope of the invention.

What is claimed is:

1. A method of indicating a position of a closure member system of an aircraft, said closure member system being positionable in an opened position, a closed position, a closed and latched position, and a closed, latched, and locked position relative to an opening of said aircraft; said method comprising:

outputting a first closed signal when the closure member system is in said closed position;

outputting a second closed signal when the closure member system is in said closed position;

outputting a first latched signal when the closure member system is in said closed and latched position;

outputting a second latched signal when the closure member system is in said closed and latched position;

outputting a first locked signal when the closure member system is in said closed, latched, and locked position;

outputting a second locked signal when the closure member system is in said closed, latched, and locked position;

analyzing the combination of said first closed signal, said second closed signal, said first latched signal, said second latched signal, said first locked signal, and said second locked signal to positively determine the position of said closure member system and produce a position signal; and

selectively outputting warnings in response to said position signal.

2. The method according to claim **1**, further comprising:

outputting an air/ground signal when the aircraft is on the ground; and

selectively outputting a first of said warnings when said air/ground signal and any one of said first closed signal, second closed signal, first latched signal, second latched signal, first locked signal, and second locked signal are received.

3. The method according to claim **2**, further comprising:

selectively outputting a second of said warnings when said first closed signal and said second closed signal are simultaneously received, when said first latched signal and said second latched signal are simultaneously received, or when said first locked signal and said second locked signal are simultaneously received, irrespective of whether said air/ground signal is received.

4. The method according to claim **1** wherein said warnings comprise a visual warning and an aural warning.

5. The method according to claim **4**, further comprising:

selectively disabling one of said visual warning and said aural warning.

6. The method according to claim **5** wherein said selectively disabling one of said visual warnings and said aural warnings, further comprising:

outputting a visual indication generally adjacent said closure member system and in a flight deck of the aircraft of said disabling one of said visual warning and said aural warning.

7. The method according to claim **1**, further comprising:

outputting a hydraulic pressure signal when a hydraulic pressure is being applied to said closure member system; and

selectively outputting said warnings when said hydraulic pressure signal is received and said closure member system is in said closed, latched, and locked position.

8. An indication system for an aircraft, said indication system comprising:

a closure member system positionable in an opened position, a closed position, a closed and latched position, and a closed, latched, and locked position relative to an opening of the aircraft;

a first closed sensor and a second closed sensor each coupled between said closure member system and the aircraft, said first closed sensor and said second closed sensor each independently operable to output a signal when said closure member system is in said closed position;

a first latched sensor and a second latched sensor each coupled between said closure member system and the aircraft, said first latched sensor and said second latched sensor each independently operable to output a signal when said closure member system is in said closed and latched position;

a first locked sensor and a second locked sensor each coupled between said closure member system and the aircraft, said first locked sensor and said second locked sensor each independently operable to output a signal when said closure member system is in said closed, latched, and locked position; and

a dual channel logic system operably coupled to each of said sensors, said dual channel logic system outputting a discrete warning in response to said signals of each of said sensors.

9. The indication system according to claim **8**, further comprising:

an air/ground sensor mountable to the aircraft, said air/ground sensor capable of outputting an air/ground signal when the aircraft is on the ground,

said dual channel logic system being operably coupled to said air/ground sensor for receiving said air/ground signal so as to output said discrete warning in response to said air/ground signal.

10. The indication system according to claim **8**, further comprising:

a hydraulic pressure sensor disposed within said closure member system, said hydraulic pressure sensor outputting a signal when hydraulic pressure is detected within said closure member system,

said dual channel logic system being operably coupled to said hydraulic pressure sensor for receiving said signal from said hydraulic pressure sensor so as to output said discrete warning in response thereto.

11. A method of indicating a position of a cargo door system of an aircraft, said cargo door system being positionable in an opened position, a closed position, a closed and latched position, and a closed, latched, and locked position relative to an opening of said aircraft; said method comprising:

outputting a first closed signal and a second closed signal when the cargo door system is in said closed position;

outputting a first latched signal and a second latched signal when the cargo door system is in said closed and latched position;

outputting a first locked signal and a second locked signal when the cargo door system is in said closed, latched, and locked position;

outputting an air/ground signal when the aircraft is on the ground;

analyzing the particular combination of said first closed signal, said second closed signal, said first latched signal, said second latched signal, said first locked signal, and said second locked signal to positively determine the position of said cargo door system and produce a position signal; and

selectively outputting warnings in response to said position signal.

12. The method according to claim **11**, further comprising:

selectively outputting a first of said warnings when said air/ground signal and any one of said first closed signal, second closed signal, first latched signal, second latched signal, first locked signal, and second locked signal are received.

13. The method according to claim 12, further comprising:

selectively outputting a second of said warnings when said first closed signal and said second closed signal are simultaneously received, when said first latched signal and said second latched signal are simultaneously received, or when said first locked signal and said second locked signal are simultaneously received, irrespective of whether said air/ground signal is received.

14. The method according to claim 11 wherein said warnings comprise a visual warning and an aural warning.

15. The method according to claim 14, further comprising:

selectively disabling one of said visual warning and said aural warning.

16. The method according to claim 15 wherein said selectively disabling one of said visual warnings and said aural warnings, further comprising:

outputting a visual indication generally adjacent said closure member system and in a flight deck of the aircraft of said disabling one of said visual warning and said aural warning.

17. The method according to claim 11, further comprising:

outputting a hydraulic pressure signal when a hydraulic pressure is being applied to said closure member system; and

selectively outputting said warnings when said hydraulic pressure signal is received and said closure member system is in said closed, latched, and locked position.

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